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ABSTRACT

This paper is concerned with the teaching-learning strategy of the Primary Science Project of the Science Education Program for Africa. It was presented in the 1976 seminar of the International Institute for Educational Planning (IIEP) of the UNESCO in Paris. The document includes six sections: (1) The concept of a strategy; (2) Description of the strategy; (3) Advantages and disadvantages of outcomes; (4) Development and implementation in Ghana; (5) The role of formative evaluation; and (6) Implications. The description of the strategy includes influence of teachers' decisions, time for learning, goals of learning, content of learning activities, structure of learning sequences, pupils' role, influence of diagnostic feedback, ideological bases of the strategy, and origin of the strategy. The implications discuss curriculum planning policy, teacher training and allocation of resources. (HM)

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IIEP seminar paper: (30)

THE TEACHING-LEARNING STRATEGY OF THE PRIMARY SCIENCE PROJECT OF THE SCIENCE EDUCATION PROGRAMME FOR AFRICA

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I. THE CONCEPT OF A STRATEGY

Activities of teachers and pupils at the classroom level have a certain consistency. There might be widespread rote learning, practical work, reading, lecturing and other activities. Whatever the situation, there is usually a conscious set of decisions demanding that things should happen that way. These decisions - the process by which they are made and implemented - reflect a strategy for learning and teaching.

The primary science project of the Science Education Programme for Africa (or SEPA science) adopts a strategy characterized by the use of the total environment, enquiry and of direct experience for learning purposes. The strategy evolved from joint discussions by representatives of African Ministries of Education, scholars and educators. It was made explicit originally at an international workshop in 1960 on science education for the newly independent African States. It was further embellished at another international conference held in Kano (Nigeria) in 1965 which brought together teachers, educational administrators, and professional scientists and science educators. Subsequently, workshops were held each year at the international level during 1965-1967 and at national level from 1965 to date. Several specific workshops have been held for teachers, teacher trainers and for education officers from time to time since 1967.

The strategy has also been articulated in a variety of memoranda issued within Ministries of Education for the purpose of establishing and assisting curriculum development institutions and for the guidance of supervisors for the evaluation of school activities. Also, each of the unit guides produced under SEPA science carries a statement of explanation to the teacher, describing in some detail what the strategy is, and how the suggested materials might be used in the classroom. The films produced also aim at articulating the strategy even further to the teacher or teacher trainer. The few readers for pupils, while not explicitly describing the strategy to the pupil, make clear suggestions that the value of the reading lies in the child carrying out some investigations which might test his ideas. As a rule, the teacher is encouraged to explain to the pupils what they are expected to do and their rôle in the learning process.

It was very important to explain the strategy to the administrators so that they can help incorporate it in their policy recommendations and also to enable them to give essential support to development teams and teachers

involved in the trial phases of the project. It was equally essential to involve teachers in the understanding of the strategy otherwise there would be no way of implementing it in the classroom. Headteachers and supervisors had to be introduced to the strategy because it was a dramatic departure from what they would expect from classroom practice under the older system.

Since the strategy is child-focussed, it is deemed applicable in other subjects besides science. Subjects like literature, social studies, mathematics, and art are suitable for the heuristic inductive approach inherent in the SEPA learning-teaching strategy. Any subject which involves deductive reasoning is also suitable for the use of enquiry processes in learning. It is, however, very doubtful if the strategy is useful for teaching subjects that cannot be learned except through rote learning and drill exercises.

The primary concern of the strategy is the child and science is regarded only as one medium for developing the child's attributes along certain directions while taking into consideration the society in which the child lives. Specifically, the following objectives are paramount.(1)

(1) First-hand familiarity with a variety of biological, physical, and man-made phenomena in the world around the child ;

(2) Interest in the further exploration of that world on the child's own initiative ;

(3) ability to explore that world - to see problems and to be able to resolve them ;

(4) having confidence in one's own ability to find out and to do things on one's own

(5) ability to share in a common development of knowledge through collaboration on problems, through listening, telling and through discriminating use of secondary sources of knowledge.

In order for instructional materials to further these goals, they have to satisfy certain criteria:(2)

(1) The focus of study should be a concrete phenomenon itself, e.g. plants, animals, stones, liquids, stars, etc.;

(2) The materials should capture and hold the child's interest and attention ;

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(1) E.A. Yoloye, Evaluation for Innovation, Education Development Centre, Newton (Mass), 1971

(2) Ibid.

(3) The materials should reveal that there is not always one right answer;

(4) Materials should allow opportunities for a variety of ways of finding out (e.g. patient observing, logical thinking, use of books, imaginative guessing, some frustration, and some inspiration);

(5) The materials should be simple and familiar so that children can go on without too much assistance from the teacher;

(6) They should encourage the child to do things on his own and in his own ways;

(7) Their use should lead to social interaction among pupils in a class.

II. DESCRIPTION OF THE STRATEGY

Influence of Teachers' Decisions

Teachers' decisions form an important part of the development feedback to the curriculum team concerning what seems to work well and what does not. But in terms of action in the classroom, the strategy demands that teachers make instructional decisions with the full participation of the learners or, at the very least, with the learners' interests given paramount consideration. The strategy is not violated if a teacher chooses the topic of study for the class, but it would be violated if the teacher then proceeded to decide on his own the content, sequence and range of activities within that topic because those are determined by the children's interest, intellectual stage of development, and probably physical maturity if construction of "equipment" might be necessary. But the teacher has to provide materials that the children might need. Almost continuously he diagnoses, appraising the children's efforts, imagination, excitement, and frustrations. He has to make decisions regarding individual children and regarding the class as a whole without interfering with their inquiry activities and without changing their tempo and direction. At the same time the teacher must be himself - expressing his own interests. Thus, he has responsibility to the child, to the group, and to himself; and far from being passive, he is as actively involved in the learning as the pupils. He might pose probing questions, suggest fruitful directions for investigation, and draw children out to express themselves. In that sense, he serves as a guide and helper but not as a director.

Time for Learning

Since children are allowed to find things out in their own way and to use different ways of finding out, there has to be a great degree of flexibility in the time allowed for learning. Children progress at different rates and will complete different numbers of activities in a given time. The time allowed depends to a large extent on the individual and small-group needs.

Goals of learning

Within the framework of the strategy, the teacher's goals are to nourish children's curiosity about their environment and to develop their powers of observation and inquiry. The teacher also aims to cultivate in the children constructive attitudes to problem-solving and decision-making when carrying out scientific investigations. The objective of problem-solving is to enable young people to discover their own strengths and to nourish them so that they can approach other problem situations with confidence and integrity. From all these activities, it is hoped that the children will also acquire the main ingredients of knowledge - the fundamental principles, the use of those principles, how to communicate them, how to design experiments, and how to co-operate with one another. These goals are the same for all children although at any given moment emphasis may be on one or the other.

Content of Learning Activities

The strategy emphasizes repeatedly in the instructional materials that there is no prescription for dealing with specific situations arising out of learning encountered. The materials are only examples of what happened in some encounters. Thus there are illustrations of what often happens when the strategy is used in the first three classes of primary school and of what happens in the upper classes. In the lower primary classes, there is provision for individual variations. In fact the strategy suggests that it is best for the children in these classes to learn in an environment where all kinds of materials are available - dry sand, wet sand, water, wood, tools, etc. and children can choose the materials they wish to use at will. The materials provided generally encourage the development of motor skills and concepts such as conservation. In the upper primary classes, provision is made for variation within one topic. In animal or plant observation activities, children are free to select whatever aspect they want to observe and can choose what investigations

to carry out. It would, however, be very rare for children in one class to be doing work in different science topics at the same time.

Structure of Learning Sequences

The sequence of learning is determined by the child's own interest and stage of development. Implicit in SEPA science is the idea of a "spiral curriculum" in which most concepts can be reconstructed by the learner in consonance with the stage of cognitive development reached. Sequencing is therefore based on the needs of the child rather than on the demands of the logical structure of things to be taught. The developed materials bear this out - there is no sequential arrangement from one unit to the other in terms of scientific subject matter.

Pupils' Role

Learning is both a physical and an intellectual activity. The SEPA science learning strategy has identified a number of actions which one would observe if the strategy was followed faithfully. Under the general label of direct participation by the learner there is (theoretically) an infinite number of performances. For example, there would be direct manipulation of objects, designing and modifying of apparatus or equipment, asking questions, making suggestions about how to do things, showing new ideas when presented with materials and a great deal of other types of activity. (1) It is only in the context of a need arising out of their own activities that children are active listeners during short lectures or when an adult is helping them or when they watch a film illustrating a specific aspect of their problem.

Influence of diagnostic feedback

The teacher makes decisions with the children on the basis of diagnostic information he has gathered about them. The teacher coordinates the children's activities, provides materials when necessary, asks questions at suitable times, and helps children when they need help. In order to perform these tasks satisfactorily, the teacher has to appraise the children's efforts and their problems. All these decisions are based on diagnostic information. The central rôle of diagnostic feedback is so fundamental in the strategy that without it, the strategy might be no better than regimentation and would therefore lose its meaning.

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(1) Science Education Programme for Africa, SEPA, Accra, Ghana, 1974

Teacher-Pupil relationship

On the basis of the strategy, teacher-pupil relationships should be marked by keen, concerned and sympathetic sensitivity to one another. Such an atmosphere implies that children will give their opinion (or results of their observations) when they do not agree with what the teacher expects; they will offer suggestions about what ought to be done, i.e. what investigations to be carried out; they will offer alternative suggestions to ways of doing things. Within the cultural context in Africa, it is not necessary to reverse rôles in the context of hierarchical authority in a classroom. What the strategy demands is mutual respect of one another's efforts and a genuine interest on the part of the teacher?

Variety of Media

The strategy lays great stress on "provisioning" for learning. The teacher has to have available a variety of learning materials - tools for constructing and weighing things ; supplies of common household articles and chemicals ; pictures of scientific activities and of problems of the environment. The media produced by SEPA illustrate the variety - software, hardware, films and play materials. The accompanying literature for the teacher sensitizes the teacher to the importance of the children's individuality in learning.

Range of goals

The objectives listed earlier show that the goals which can be achieved using the strategy are very broad including as they do cognitive, affective, and motor skills development. Children are encouraged to develop social values of working with others and of weighing evidence before accepting it ; they are also expected to construct some of the equipment they use and to make tools ; they are, of course, expected to exhibit cognitive skills in problem-solving.

Ideological Bases of the Strategy

The idea of the strategy was conceived by Africans in 1960 where they insisted on the teaching of science in the primary schools not for the purpose of extolling the virtues of technology but mainly for the purpose of conveying a meaningful fundamental education. Science was viewed

as a tool for "attacking a people's world view, a philosophy of history, if you like, and changing their point of view".(1) It was the African voice which said "to all of us has come a whole realisation that science, through its constantly changing and growing insight, can be brought to bear and to liberate human kind and the human spirit". (2) Later in 1961, it was still the Africans (now supported by voices from other continents) who stated that science appears in the school "in a dual rôle, the same double part it plays in the widest stages of thought. We cannot accept an education in the twentieth century on any level which does not at least suggest the scale of space and of time, the unity in diversity of life, the instruments which transcended limits of our inborn senses, or the complex chains of cause and effect.... The primary school leaver and the brilliant student reading classics ought to share at least in the broadest outlines of the picture of the natural world and the artifacts of industry which science has built". (3) They went on to conclude that the major thrust in the learning of science should be the direct involvement of the individual child with the material he was studying - "whenever possible the pupil must himself intervene with his own thoughts, his own hands and his own will to learn".(4) "we want to include the various heuristics of science from induction, analogy, and trial and error to the more austere deduction, controlled experiment, and mathematical implication". (5)

These ideas tallied well with developmental psychology schools which maintain that early in life the child develops regularities of his environment intuitively. As new information is encountered, the child re-organises ideas already in him and in general the child associates intuitive regularities previously developed with regularities achieved

(1) Education Development Centre, Beginning Science Curriculum for English Speaking Tropical Africa (Final Report), Education Development Centre, Newton, Mass. 1971

(2) Ibid.

(3) Ibid.

(4) Ibid.

(5) Ibid.

through manipulation of objects. It is at a later stage that the child learns by picturing objects in his mind and still later that he manipulates symbols and uses language and logic to present what he has learned. The act of learning, then, involves three processes which take place simultaneously : the ability to gain new knowledge, sometimes a replacement of old knowledge; the ability to deal with available information and comprehend it to such an extent that one can go beyond it and derive new ideas, proper implications, appropriate inferences, etc.; the ability to check and make sure that one's observations, implications, inferences, consequences, etc., have justification.

Related to this view of learning is another that maintains children learn cognitive structures on the basis of functional invariants which the child uses in the physical environment. The cognitive structures help the child to organise his knowledge and also to adapt to new situations. In trying to adapt, the child might try to impose his behaviour patterns on aspects of the environment. The resulting interaction with the environment, however, may lead to new facets being added to the structure which in turn lead to new interactions with the environment. The quality of the interactions depends upon a variety of factors including the stage of mental development of the child.

Africans became more convinced of the appropriateness of the strategy they were proposing when they observed experimental classes in Kano (Nigeria) in 1965. "The children's quickness, intelligence and eagerness to learn was wholly indigenous, and it was all that was needed." (1)

Scientists, philosophers and historians of science, and some science educators have believed in direct observation as a useful way of doing science. Aristotle developed the role of direct observation and full description. Kant's contribution was in placing empiricism in a proper context within science - that truly all our knowledge begins with experience but it does not follow that it arises out of experience. Some of it is intuitive knowledge that has been built up over time from sense data and is constantly changing with encounters of new data. Darwin's view of evolution brought into centre stage the universality of cause and effect.

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(1) Education Development Centre, A report of an African Education Programme, Education Development Centre, Newton, Mass., 1967

Wright differentiated between things that are "real kinds" and those that are not - real kinds imply the Linnean classification and other kinds are classes that are similar in one or two respects, e.g. things that are yellow. He also enriched description by ascribing breadth of relationship and fixity in time to the verification of observation, and emphasized again that the value of a scientific theory lies in its predictive value.

Modern scientists and philosophers such as Einstein and Dewey re-emphasized all the foregoing and highlighted once again the value of direct participation by the learner. That is what distinguishes education from training.

Origin of the Strategy

The most crucial activity in the evolution of the strategy was the conference held in Kano in 1965. African delegates were from universities, ministries of education and from secondary and primary schools. They furnished clear statements of the needs and aspirations of their countries. These statements were considered by the entire conference, which included educators from the United Kingdom and the United States of America, and also by each national group after they had been discussed. The African delegates decided to adopt the strategy formally and to take steps to introduce it upon return to their countries. As a follow-up to that decision, a workshop was held later that year to develop concrete plans representing the strategy. Participants included university scientists and educators, ministry of education officials, school inspectors and primary school teachers. By the end of the workshop about twenty primary science units had been conceived and tested in African classrooms and suggestions made on how to make useful but inexpensive laboratory equipment from local materials. These international workshops became a regular feature.

In the case of Ghana the Ministry of Education had employed an education Officer trained in science as early as 1963. An Elementary Science Unit was established within the division of curriculum development and research, and additional science education officers were employed. Both the head of the Unit and the Chief Education Officer had been participants in Kano and had accepted the strategy and they advised the Ministry of Education on the implementation of the project.

The new strategy was part of a general education reform movement. It had been felt that the teaching of science in particular was primitive relying as it did on theoretical nature study and on rote learning. The teachers' classroom behaviour could be described as "chalk and talk". Emphasis was laid on science for other reasons - there was a shortage of trained science teachers and the intake of science students at university was completely inadequate as a result. In addition, science was viewed as an important component of a broad functional literacy campaign.

Long-term planning included the creation of curriculum development centres in the participating African countries, and the training of manpower to staff the centres and to carry out development at the national level. In the short term, a series of international and national workshops were to be organised to develop ideas for units and to acquaint teachers and supervisors with the strategy. Also, international agencies were to furnish specialist science educators to assist in the early introduction of the strategy in trial schools as well as in the training of in-service teachers and, in a few instances, in the pre-service phase also.

Feedback was provided through development staff working in teams with trial schools teachers thus affording direct observation and recording of the learning events. Sometimes teachers made notes on their lessons and sent these comments to the development team at the science curriculum development centre. Trial schools were selected by the local Ministry of Education and were expected to send regular reports. Quite early in the introduction of the strategy an evaluation team had developed feedback forms which could be used by the teacher when observing pupils.

Except in one or two countries, in the first four years there were no concrete plans for implementing the strategy on a large scale. In the few countries that had decided to implement the strategy the units were arranged sequentially in accordance with the primary school science syllabus after they had undergone adaptation locally or they were adopted as reference material for the teacher. But all the countries decided very early to embark on in-service courses for teachers and inspectors. Demonstration lessons using the units were given. Sometimes pupils were used, but at other times the in-service trainees served as pupils. In some countries teacher training colleges were selected for the wholescale

adoption of the strategy so that teachers from the colleges would receive full training in the strategy during their pre-service years.

At present the strategy is being introduced on a large scale. In some places the units have been modified and re-printed for use by all the schools; but at other places primary science textbooks have been produced for teachers. The books draw heavily from the units but include other sources while retaining the essence of the strategy. Children's workbooks have also been produced.

SEPA's own development plans to further assist in broad-scale implementation include a frontal attack on the problems of teacher training, production of materials, and evaluation. A residential training course for curriculum implementors and teacher trainers has been established. This nine-month course introduces and educates participants in the strategy as it applies to development of materials, supervision of teachers, and training of new teachers. The development of materials includes the production of monographs on specific aspects of the strategy, preparation of a handbook for teachers and of a source-book of ideas when using the strategy. A Centre for educational evaluation has also been established to train evaluators from participating countries and also to develop evaluation instruments for use in the monitoring of the strategy. The education of in-service teachers continues in each country for purposes of providing support for them in the use of the strategy and for facilitating their professional growth.

Resistance to the introduction of the strategy was expected from many corners. The primary school teachers and the school inspectors were faced with the task of abandoning traditional teaching methods with which they were very comfortable and through which they had gained professional recognition. The new strategy was bound to shake their confidence in themselves and this was resisted. University scientists were interested mainly in subject matter rather than in the heuristics of learning that the strategy called forth. Teacher trainers had found the doling of facts a much more comfortable way of teaching and of training teachers and would be resentful of the strategy which required a new role for the teacher. A powerful source of resistance was the headteacher who wanted his school to maintain a high rating on the basis of primary school leaving examination performance; to him the strategy did not seem to provide the kind of knowledge which would be teste and even if it did, it seemed to take an

inordinately long time to do so when the information could be given to the children in less than one tenth of the time. The general resentment to the introduction of science in the primary school was the belief that it would require expensive equipment which would put additional strain on the distribution of severely limited resources.

III. ADVANTAGES AND DISADVANTAGES OF OUTCOMES

The strategy created a new sense of direction for the pupils who began to find their schooling more meaningful as they were able to pursue their natural interest in nature out of school with a certain amount of confidence and understanding. Their interest was stimulated beyond the classroom and a connection began to develop between school work and activities around the home, the farm, the village and the general environment. The children began to ask meaningful questions about their environment and to use local materials when making simple scientific equipment such as balances, petri dishes, and magnifying lenses.

For many children previously, school had created feelings of inadequacy by putting them in completely new, threatening, and artificial situations. By changing all this, the result was the development of citizens who had positive feelings of themselves and who were realistic about their own capabilities. They would be able to contribute to national development with confidence and understanding.

Theoretically, the outcomes were expected to raise the morale of the teachers by making their work more challenging and exciting and by involving them directly in scientific investigations which made sense to them. It was thought that they would draw encouragement from the activities of their pupils. Further, encouraged by these experiences in science the teachers would probably use the strategy in teaching other subjects thus making it easier for the pupils to generalise the learning strategy to other areas of knowledge.

A major disadvantage that was perceived was the doubtful contribution of the strategy to rote learning. This was seen as a disadvantage largely because the primary school leaving examinations were believed to lay stress on memory rather than on reasoning and problem-solving.

The strategy is subject to certain constraints in practice. Relying so heavily on "provisioning" by the teacher, it is very sensitive to shortage of learning materials in the classroom. This is usually a great problem

as teachers often do not have time to collect materials beforehand or do not have resources to use for the acquisition of the materials. Availability of secure storage facilities for the children's experiments is another constraint. As a result, pupils often cannot proceed fruitfully after they have left their experiments overnight. Constraints of the time-table further aggravated this problem by limiting the time that pupils can spend on their investigations. The class size could be a problem. Classes with 60 or more pupils are not uncommon and the teacher would be hard-pressed to pay attention to individual pupils or sometimes even to small groups.

In spite of the constraints, however, there is evidence that the strategy yields fruitful results. One experiment (1) showed that pupils who have been learning science through the strategy performed a variety of tasks with learning materials beyond those usually listed in the teachers guide and that their activities are significantly more advanced in complexity than those of other pupils. Another study (2) found that the pupils taught through this strategy showed more independence in learning than others. Recently, one country included in its primary school leaving examination some items representative of the strategy. The results show that the strategy develops analytical abilities in children. Admittedly, the strategy is so radically different from what has been going on in African classrooms that evaluation instruments that will yield reliable results are in their infancy.

IV. DEVELOPMENT AND IMPLEMENTATION IN GHANA

Development work has gone on in Ghana since the introduction of the strategy. In 1970 the Ministry of Education published a report of a workshop which gave the official statement for the introduction of the strategy in all schools in Ghana. A great deal of adaptation also took place in seven educational regions to ensure that the materials were suitable for each part of the country and also to involve more teachers in the development process in order to spread understanding of the strategy more expeditiously.

The significance of the 1970 report was that it recommended the use of the strategy in secondary science education also as well as in teacher training colleges. Development work is now underway for these cycles of education.

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(1) E.A. Yoloye, Evaluation for Innovation, Education Development Centre, Newton, Mass, 1971

(2) Ibid.

The first phase of implementation of the strategy on a wide scale was the publication by the Ministry of Education of unit materials developed along the lines of SEPA science. These materials were included in the approved list of primary science books which means they would be supplied free to the schools requesting them. The next phase was the assembly of people who had been involved in the development of the strategy to write books for use by teachers and by pupils. Two primary science books have been prepared - one for the lower primary teachers and the other for the rest of the primary level teachers. The two books adopt the strategy and contain material which illustrates its application. The pupils book is for upper primary classes only and gives activities and exercises which help pupils to acquire the skills implied by the use of the strategy. A curriculum guide has also been prepared to help the teachers know the objectives of science education and the kinds of activities that can help in their achievement. It also contains suggestions on how to test for their achievement. The guides are prepared for each class of the primary school except the first three.

Teacher education was embarked upon very early in the development phases. Teachers were introduced to the strategy through in-service courses run at the national, regional and district levels under the auspices of the Ministry of Education and the Ghana Association of Science Teachers (GAST). In addition, courses for regional science education officers were held in each region and also nationally, and those for district officers were held regularly for the district science organisers. In the in-service courses for teachers, the teachers who had attended international workshops on th on the strategy and those who has been involved in the trial usage of the units played a crucial role in educating others. It was these teachers who became a nucleus of teacher education activities and who served as pioneers of the strategy in their districts and regions. The courses for teachers were conducted by the staff of the Elementary Science Unit (now renamed the Science Unit) who were under a Principal Education Officer responsible for science and courses.

The staff of the Science Unit also worked directly with primary teacher training colleges to assist the teacher trainers in the introduction of the strategy at that level. The teacher training and primary science panels of GAST played a leading role in the promotion of the strategy at this level.

To further assist in implementation the schools' television broadcasts employed the strategy. This enabled some teachers to observe the strategy in action from someone who had been trained through it. It also enabled them to see the wide range of activities that pupils were capable of carrying out.

The problems in large-scale implementation lay mostly with the teacher. Large numbers of teachers had to be retrained within a short time and without the benefit of a good background in science. The absence of that background might be an advantage, however, since it meant they had not been indoctrinated with outdated ways of teaching science. There was the additional problem of insufficient monitoring of progress and of providing support measures for the teachers as they were learning to play a new role. District supervisors were unequal to the demands as they had to visit a large number of schools within their district and very often were called upon to do administrative chores.

At the teacher training college level, the problem related to the fact that very often the teaching aimed at preparing the students for the secondary school examinations. Since these examinations aim at different goals, the students lost interest in any strategy that did not prepare them specifically for the examinations. Even in cases where they were not being prepared for the examination, the teacher educators felt that the students had no background in science and that, therefore, they had to improve their science knowledge by giving them facts. The real problem, of course, was that the science teacher educators themselves were unfamiliar with the strategy.

V. THE ROLE OF FORMATIVE EVALUATION

An evaluation unit was established early as an integral part of the development phase. The early attempts of the unit served the purpose of exposing the immensity of the problem of evaluation. Later, the unit helped to clarify what the nature and goals of the strategy were and started to develop evaluation instruments and techniques. Formative evaluation helped to raise questions such as (1) : how do I know that a unit works? What does a particular unit in fact do? How do I know that a child is learning? How best can the spirit of the teaching-learning strategy be communicated

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(1) E.A. Yoloye, op.cit.

to the teacher? What predisposing characteristics in the child or the teacher aid or hinder learning this way?

As a result of formative evaluation the key problem diagnosed is teacher training. It must be so because the strategy is not just a list of scientific content to be taught to children, but more of a way of working with children. "Until the problem of teacher training is solved, i.e., the problem of how one gets the primary school teacher to interpret and practise correctly (the teaching-learning strategy), evaluation of outcomes on the children, teachers and others will remain seriously handicapped". Much of the effort on the formative evaluation of the strategy has focussed on the development of a number of classroom interaction analysis and child development techniques. Through this effort useful data for the developer have been furnished.

VI. IMPLICATIONS

Curriculum Planning Policy

Quite clearly, within this strategy curriculum development is a partnership of developers, teachers, administrators and pupils. The development team itself would consist of science educators, scientists and teachers who generate ideas; evaluators who articulate the goals and objectives and who devise mechanisms for monitoring and improving development; teachers who try out the strategy practically and serve as a resource on local materials and the pace at which they can be used; and the schoolchildren who are the actual test of what works, what is interesting, and how far the materials can be used to facilitate their learning. It is quite clear that it will not be useful for a developer to sit in his office and churn out books for schools without satisfying these criteria practically.

A science curriculum development centre has been the cornerstone in the development of the strategy. Whatever it looks like, it essentially is the team described above. It is a science center that converts ideas into useful teaching materials and it is the children who ultimately decide what is usable. Local resources vary very widely in Africa even within one country and it is for that reason that a science centre is useful in taking account of the local situation. Regardless of how specific the objectives and the guidelines for teachers are, there will always be a need to help the teacher decide which materials stimulate the child to probe and to learn, how best the materials can be presented in the classroom, what additional information the teacher needs to best perform her

rôle, and what useful indices to use to evaluate learning. A science centre can provide those services.

Science centres will be different institutions in different places even within the same strategy. From SEPA's experience a general statement on the composition of staff of science centres is that it should consist of a core of trained and dedicated people who are knowledgeagle in all phases of science education and who can impart enthusiasm to others. It was found useful to have a science educator, a teacher, an evaluator, and a craftsman. This is the barest minimum for a small country. An important factor to consider is not the number of people but the kinds of people forming the core. Two imaginative and resourceful people can be better than five who are at best passengers. The imaginative people who have the ability to get others moving end up having professional support from all kinds of corners. In the evolution of the SEPA strategy university scientists, professional educators, school inspectors, school supervisors, teachers and school children have been employed. An important rôle has also been played by psychologists, psychiatrists, sociologists and economists. The utilisation of these specialists stemmed from the belief that education, especially science education, is too important a task to be left only to the specialists.

Specifically, within the SEPA strategy objectives are stated in general terms but teachers and administrators are furnished with guidelines on what to look for and expect from pupils. Teachers choose what directions to follow depending on the interests and abilities of pupils. In attempts to assess what other objectives are served by the strategy, teachers are furnished with simple instruments to help them collect data on their pupils' learning behaviours.

The strategy included the development of readers for children who might be interested in pursuing some line of thought. The readers are written in a language style that can be easily understood by the child and they adopt a story line approach. No attempt has been made to develop remedial material as it is believed there is enough flexibility within the regular materials to allow for differential abilities.

Materials under the strategy are developed in unit form. On the average each unit would contain six to eight lessons. Each unit is largely a re-enactment of the learning situation and learning events that occured as well as how they arose. Useful materials are listed at the beginning of each lesson and suggestions are made to the teacher about checking whether pupils understand what they are doing. Practically all the units

are written for teachers. Some of the units include specific directions to the teacher and others are non-directive. The directive parts concern techniques for constructing needed equipment. To date over fifty such units have been printed covering the biological and physical sciences as well as health and agricultural education. Teachers' handbooks and monographs have been produced and a sourcebook of ideas for activities is under preparation. A start has also been made on selecting a single unit and enriching it by including background science activities and ways of evaluating pupil activities. Several films showing the strategy in action in ordinary classrooms and at teacher training colleges have been produced. The production costs have been minimal as the printed materials can be reproduced by lithographic methods. When printing very large numbers, the unit cost is no more than twenty cents (American dollar base).

Teacher Training

The in-service education of teachers has been carried out largely by members of development teams and by specially trained teachers and science supervisors. Training carried out by the development team ensures reasonable certainty that the strategy is being carried out faithfully. Through working directly with in-service teachers and supervisors, the team gets a "feel" of the problems the teachers are likely to have and of the misgivings they have (if any). Use of teachers who gained experience through the trial phases can be very useful in dispelling the notion that the strategy works only if employed by specialist staff.

At the pre-service stage the strategy was introduced by involving students in the way they were expected to use it. Sometimes even the topics selected could be found in the schools science syllabus. In the early stages the students perform like a class; but later in the course they work with small groups of pupils using the same topics they had investigated. Still later, they use regular primary school classes. The later modifications are aimed at giving the students familiarity with the ways in which pupils learn. A set of materials has been prepared for the training college student - illustrations of work of other students, pupils, and of scientists. There are also special sections on relating with children and on provisioning for a primary science class. Some materials deal with techniques of questioning, evaluating pupil progress, and of self-evaluation. Monographs on special aspects of teaching have also been prepared.

During training courses for teachers, the strategy was used in what was believed to be its pure form. The teachers would be given learning material e.g. torch batteries, bulbs, and a copper wire and several other

things which could be used to make scientific investigations. After about thirty minutes or so, the teachers being used as learners would report what they did with the materials, why they did it, and what kinds of learnings they derived. These were recorded on a chalk board by the team member conducting the lesson. Afterwards their activities were analysed by the group as to their meaning and value in the learning of science. These values were contrasted with what would have been derived by children if they had been taught by the lecture-and-notes method. Later, the same lesson was conducted with pupils and the teachers served as observers and evaluators. After the lesson, a discussion would be held on the meaning and value of the pupils' activities. Teachers were also given opportunities to construct some simple equipment for their own use and which they could take to their schools. It was stressed that they keep a complete record of what they saw happening during the course. Some of these requirements were made to counteract the expectation to be given notes by the course organisers and to be given equipment like test tubes, beakers, etc. All attempts were made to enable teachers believe that children can learn from their activities and that they can make their own notes which are meaningful to them. Herein lay the value of teachers undergoing experience in deciding their own investigations and carrying them out during training courses. They build confidence in themselves which is later useful in building confidence in the pupils.

In most cases the practical experience of using a class where pupils are working in smaller groups and the desks are not arranged in rows but in a manner which facilitates working in groups, was sufficient to make the teachers realise they were using a radically different strategy. It was found useful to introduce teachers immediately into the complete change and to get them used to listening to children. Most teachers were very sensitive to "noise" by the pupils and they had to learn that small group discussions about learning activities are not "noise". Any gradual introduction (meaning a dilution of the strategy) did not seem to work very well. The introduction of the strategy implied that time-tabling has to be flexible and the courses have to be much longer than usual. Also the objectives of the courses would have to be modified so that the expectation by the staff is one of creating salutary attitudes towards the strategy rather than complete mastery initially. A new feature in the course was the presence of pupils, which meant that courses had to be carried out during school terms or additional facilities for obtaining pupils would have to be created and time given for teachers to interact with the pupils during the course.

In most cases, workshops were held earlier for school inspectors and education officers. They too were introduced practically - carrying out investigations in the manner the strategy required and then observing the strategy in action in a class. Discussions followed in which roles of the supervisory and administrative staff were spelled out. Problems arose when the principals and supervisors could not reconcile their roles of being administrative with those of being professional and the regulatory constraints on the time allocated to various subjects. These problems were reduced by the knowledge that the Ministry of Education had foreseen the problems and had introduced flexibility on the items education officers had to report on. The task of informing parents was left to the principals and supervisory staff.

Allocation of Resources

Large rooms are more suitable than regular classrooms but in the participating schools there was no need for structural alterations. There was certainly unusual spacing and arrangement of desks. Bench desks are most unsuitable. Preference should be given to individual sitting desks which can be shifted easily in the classroom. Equipment used by pupils is very durable - made of plastic. Most of it need not be durable as it can be made quite easily from construction paper or can be procured free of charge, e.g. bottle caps, empty tin cans, etc. The strategy can be carried out in regular classes without special grading, parent participation or teacher aids.

Groups of two or four pupils are ideal when using the strategy. The grouping works best when the pupils choose their own partners or group mates. In outdoor activities requiring use of playground equipment, larger groups (six to eight) are recommended to allow for greater variation.

Storage facilities are essential. These would normally be cupboards and small cages for animals. There is usually a need for space to keep acquaria and terraria and the tops of the cupboards might be sufficient for this purpose. Security has been found to be a problem in many cases if the classrooms cannot be locked.

The strategy does not require special monitoring devices going beyond what the teacher would use - record book, notebooks, and activity sheets. There is no need also for special corners or teacher aids. Pupils with unusual difficulties in carrying out their experiments can be helped during regular time without disturbing the rest of the class.

Built-in costs include the cost of establishing and maintaining a core of staff at a centre and also of employing support staff at the district and regional levels for science education only. In the early stages, these support staff would have to be relieved of administrative duties they would otherwise perform in addition to their professional work. The greatest single outlay of financial commitment is in the development stage. The development, testing, evaluation, and revision are expensive compared to the traditional preparation of materials in Africa. The development of the teacher training aspect is not as expensive as it might appear because the strategy was introduced as part of a general curriculum reform movement. However, the cost factor is crucial in the early stages, but its introduction on a national basis increases costs only marginally. Unfortunately it is impossible to compare with the cost of other strategies in the past as science was not taught in the primary schools.

In most countries a greater portion of the development costs was born through budgetary allocations by the local Ministry of Education and was supplemented through extra-budgetary sources from international and bilateral assistance organisations. Currently, the Science Education Programme for Africa bears a large portion of the extra-budgetary contribution. During the testing the Ministry of Education paid for the cost of materials and for specialists who assisted the local staff.

The extra costs of implementation are likely to be met by the Ministries of Education. It has been stated already that the cost of production of the materials is being borne entirely by the Ministries. The training and re-training of teachers is being financed by the Ministries of Education, but the cost of non-national specialists is borne by international agencies. SEPA furnishes such specialists upon request at no charge to the countries which are members. SEPA also furnishes limited funding for supply of materials during the training courses for use by the specialists.

In conclusion it should be stated that systematic evaluation of the strategy at the implementation stage will be carried out in the years to come. The strategy has been introduced on a large scale only recently and there has been no examination in science at the end of the primary school. But as the countries have decided to adopt it, there will be evidence from the field as to how beneficial the strategy is and just how effective it is in achieving the objectives mentioned earlier.